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CHAPTER

STRUCTURE OF MOLECULES

MULTIPLE CHOICE QUESTIONS

1. **Elements of group 18 are called:**
   (a) noble metals (b) noble gases (c) noble (d) none of these
2. **Element attaining eight electrons in its outermost shell are called**
   (a) duplet rule (b) octet rule (c) both "a" and "b" (d) none of these
3. **The force of attraction which holds the atom together is called**
   (a) ionic bond (b) covalent bond (c) hydrogen bond (d) chemical bond
4. **Every atom tries to attain**
   (a) maximum energy (b) stable energy (c) minimum energy (d) covalent energy
5. **Which force of attraction is present between positive and negative ions?**
   (a) homolytic (b) electrostatic (c) electro elastic (d) electronic
6. **A bond formed by the complete transfer of electron from one atom to other is called**
   (a) chemical bond (b) covalent bond (c) ionic bond (d) metallic bond
7. **Hydrogen acquires the electronic configuration like**
   (a)Xe (b) Ne (c) He (d) Ar
8. **In non polar covalent bond the bonded atoms share the electrons**
   (a) not equally (b) equally (c) differently (d) oppositly
9. **In polar covalent bonds molecules are**
   (a) homo atomic (b) tri atomic (c) hetero atomic (d) mono atomic
10. **Dipole-dipole interactions are**
    (a) magnetic (b) electric (c) neutral (d) stable
11. **Energy requires to break forces of one mole liquid HCl molecule is**
    (a) 16kJ (b) 15kJ (c) 17kJ (d) 18kJ
12. **The density of ice at $0^{\circ}C$ is**
    (a) 0.917 gcm^{-3} (b) 0.719 gcm^{-3} (c) 0.197 gcm^{-3} (d) 0.0917 gcm^{-3}
13. **One form of polymer used industrially as a adhesive**
    (a) epoxy (b) explosive (c) synthetic (d) natural
14. **Epoxy is a polymer formed by the resin and**
    (a) shiner (b) softener (c) hardener (d) thiner
15. **Substance have the tendency to gain electrons and anions**
    (a) metals (b) non metals (c) metalloids (d) halogens
16. **Which properties are affected by hydrogen bonding**
    (a) physical (b) chemical (c) ionic (d) metallic
17. **Which scientist had given the idea of octaves in periodic table?**
    (a) Mendeleev (b) Al-razi (c) Newland (d) Dobereiner

ANSWER KEY

1	b	4	c	7	c	10	c	13	a	16	a
2	b	5	b	8	b	11	c	14	d	17	c
3	d	6	c	9	c	12	a	15	d	KIPS	

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SHORT QUESTIONS

4.3 TYPES OF CHEMICAL BONDS

Q.1 Why does sodium form a chemical bond with chlorine?

Ans. Sodium form chemical bond with chlorine because, sodium has only one electron in its valence shell while, chlorine has seven electron in its valence. Sodium is electropositive in nature, so by losing its valence electron, it attains noble gas electronic configuration while chlorine is electronegative in nature gain an electron to become stable.

Q.2 Why does sodium lose an electron and attains +1 charge?

Ans. Sodium is electropositive in nature, it easily loss its valence shell to attain its stability and electronic configuration like noble gas helium.

$$Na_{11} \xrightarrow{\text{loss one electron}} Na^{+} + 1e^{-}$$
$$(2,8,1) \qquad\qquad (2,8)$$

Q.3 How do atoms follow octet rule?

Ans. To attain 8 electron configuration in the outermost shell either by losing, gaining or sharing electrons, is called octet.

So all atoms except hydrogen and helium obey octet rule to attain electronic configuration and stability like noble gas (Ne, Ar, etc)

Q.4 Which electrons are involved in chemical bonding?

Ans. Only valence shell electrons are involved in chemical bonding.

Q.5 Why does group 1 elements prefer to combine with group 17 elements.

Ans. Because, all the elements of group I have one electron in their valenece shell. They are electropositive in nature and lose their outermost electron easily. That one loosed electron easily gained by the elements of 17th group that require only one electron to attain configuration like noble gases.

Q.6 Why chlorine can accept only 1 electron?

Ans. Chlorine have seven electrons in its outermost shell as:

It requires only one electron to complete its valence shell, electronic configuration like Argon (Ar_{18}). So, it gains one electron from the elements of 1st group mostly.

Q.7 Give the electronic configuration of carbon atom.

Ans. The electronic configuration of carbon is $_{6}C = 1s^2, 2s^2, 2p^2$

Q.8 What type of elements have tendency of sharing of electrons?

Ans. The elements with low electronegativity values have the tendency to form covalent bonds. The elements of group 13 to group 17 usually form bonds of sharing of electrons. Because, they have three to six electrons in their valence shells. This electronic configuration is good to make covalent bonds.

Q.9 If repulsive forces dominate, attractive forces will a covalent bond be formed?

Ans. No, there will not be covalent bond formation if repulsive forces dominate to attractive forces. Because, the bond formation takes place when the attractive forces dominate due to decrease in distance between those two of atoms.

Q.10 Considering the electronic configuration of nitrogen atom, how many electrons are involved in bond formation and what type of covalent bond is test yourself formed.

Ans. Electronic configuration of nitrogen is $_{7}N = 1s^2, 2s^2, 2p^3$

So, three electrons are involved in bond formation of nitrogen atom. As shown in equation:

$$:\dot{N}\!\!:\; + \;\overset{\times}{\underset{\times}{\times}}N\overset{\times}{\times} \longrightarrow \;:N\!\!\vdots\overset{\times}{\underset{\times}{\times}}N\overset{\times}{\times}$$

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Q.19 What type of elements form metallic bonds?

Ans. Metals form metallic bonds in them. Because metal atoms are positively charged atoms which have mobile or free electron in them.

Example: (i) Sodium Atom have one mobile electron.
(ii) Calcium atom have two mobile electron.

Q.20 Why is the hold of nucleus over the outermost electrons in metals weak?

Ans. The hold of nucleus over the outermost electrons is weak because of large sized atoms and greater number of shells in between nucleus and valence electrons because of shielding effect.

Example: Sodium required more energy to lose outer most electron then potassium.

Q.21 Why the electrons move freely in metals?

Ans. Metals have low ionization potentials hence metals have the tendency to lose their outer electrons easily. Resultantly, these lose or free electrons of all metal atoms move freely in the spaces between atoms of a metal. None of these electrons is attached to any particular atoms. Nuclei of metal

Q.22 Which types of electrons are responsible for holdings the atoms together in metals?

Ans. Mobile electrons present within the metals are responsible for holding the atoms of metals together forming a metallic bond. Metals have the tendency to loose their electrons, these electrons are known as mobile electrons.

4.4 INTERMOLECULAR FORCES

Q.1 Define intermolecular forces; show these forces among HCl molecule.

Ans. Intermolecular forces are those forces which are relatively weak forces also exist in between the molecules. These forces are shown in hydrogen chloride molecule.

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Q.2 Why a dipole develops in a molecule?

Ans. Dipole develops in a molecule as a result from the attractions of opposite charges which may be temporary or permanent. The unequal sharing of electrons between two different types of atoms make one end of molecule slightly negatively charged due to difference in electronegativity.

For example: $H^{\delta+}$—— $Cl^{\delta-}$------ $H^{\delta+}$—— $Cl^{\delta-}$------ $H^{\delta+}$ —— $Cl^{\delta-}$

Q.3 What do you mean by induced dipole?

Ans. Induced Dipole: When partial positive and partial negative charges exist at different positions in a molecule, the adjacent molecules with arrange themselves in such a way that negative portion of that molecules come near to positive portion of other molecule. It results in a net forces of attraction between oppositely charged portions of two adjacent molecules.

For example: $H^{\delta+}$—— $Cl^{\delta-}$------ $H^{\delta+}$ —— $Cl^{\delta-}$

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Q.4 Why are dipole forces of attraction not found in halogen molecules?

Ans. Intermolecular forces exist between the HCl molecules. These intermolecular forces are known as dipole-dipole forces. Because Halogens form diatom which are similar and having no electronegitivity difference that's why they don't have dipole--dipole interaction.

Example: Cl_2, I_2, Br_2 and F_2

Q.5 What types of attractive forces exist between HCl molecules?

Ans. Intermolecular forces exist between the HCl molecules. These intermolecular forces are known as dipole – dipole forces. Hydrogen have less electronegativity then chlorine so chlorine attracts share pair electron towards itself and acquire small negative charge and hydrogen acquire small positive charge. That's why dipole – dipole interaction develop between HCl molecules.

Example: $H^{\delta+}$ — $Cl^{\delta-}$------ $H^{\delta+}$ — $Cl^{\delta-}$

4.5 NATURE OF BONDING AND PROPERTIES

Q.1 Why the ionic compounds have high melting and boiling points?

Ans. Ionic compounds have high melting and boiling points. For Example, sodium chloride had melting point 800°C and a boiling point 1413°C. As ionic compounds are made up of positive and negative ions, there exist strong electrostatic forces of attraction between oppositely charged ions. So, a great amount of energy to break these forces.

Q.2 What do you mean by malleability?

Ans. Malleability is a special property of metals. By virtue of this property metal can be drawn into sheets

Example: Silvers can be convert into foils or sheets by applying pressure.

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Q.3 Why are ionic compounds easily soluble in water?

Ans. Ionic compounds are easily soluble in water. Because water is a polar solvent. Water has high dielectric constant that weakens the attraction between ions.

Example: Sodium chloride can easily soluble in water.

Q.4 What type of bond exists in ionic compounds?

Ans. Ionic bond exist in ionic compounds which is formed by the complete transfer of electrons among different atoms.

Example: $BaCl_2$ having ionic bond in which Barium is cation and chloride is anoin.

Q.5 Why the covalent compounds of bigger size molecules have high melting points?

Ans. Bigger size covalent molecules have three dimensional bonding in them, which form covalent crystals which are very stable and hard. So, they have high melting and boiling points.

Example: Diamond, Graphite, Buck balls

Q.6 How much there is electronegativity difference between the following pair or elements (atoms). Predict the nature of the bond between them?

(a) Hand Cl **(b) Hand Na** **(c) Na and I** **(d) KandCl**

Ans.

Air of Elements	Electronegativity differences	Nature of bond
(a) H and Cl	0.9	Polar covalent bond
(b) H and Na	1.2	Ionic bond
(c) Na and I	1.6	Ionic bond
(d) K and Cl	2.2	Ionic bond

Q.7 Comparing the electronegativity differences, arrange these compounds in increasing ionic strength.

Ans. $0.9 < 1.2 < 1.6 < 2.2$

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LONG QUESTIONS

Introduction

The things around us are composed of matter. All matter is made up of the building units 'atoms'. These atoms combine to form molecules, which appear in different states of matter around us.

Chemical bond

The forces responsible for binding the atoms together in a molecule are called chemical forces or chemical bonds.

Q. No. 1 Why do atoms form chemical bonds?

4.1 WHY DO ATOMS FORM CHEMICAL BONDS?

Atoms achieve stability by attaining electronic configuration of inert gases (He, Ne or Ar etc) i.e. ns^2 np^6 having 2 or 8 electrons in the valence shell is sign of stability.

- An atom having two electrons in the valence shell is called duplet rule.
- An atom having eight electrons in the valence shell is called octet rule.

Why noble gases are non reactive?

The noble gases do have 2 or 8 electrons in their valence shells. It means all the noble gases have their valence shells completely filled. Their atoms do not have vacant space in their valence shell to accommodate extra electrons. Therefore, noble gases do not gain, lose or share electrons. That is why they are non-reactive.

The importance of the noble gas electronic configuration

The importance of the noble gas electronic configuration lies in the fact that all other atoms try their best to have the noble gas electronic configuration. For this purpose atoms combine with one another, which is called chemical bonding. In other words, atoms form chemical bonds to achieve stability by acquiring inert gas electronic configuration.

How atoms can acquire electronic configuration of noble gases?

An atom can accommodate 8 electrons in its valence shell in three ways:

- By giving valence shell electrons (if they are less than -three) to other atoms.
- By gaining, electrons from other atoms (if the valence shell has five or more electrons in it)
- By sharing valence electrons with other atoms.

It means every atom has a natural tendency to achieve 2 or 8 electrons in its valence shell. The atoms having less than 2 or 8 electrons in their valence shells are unstable.

How can we identify the way an atom reacts?

- The position of an atom in the periodic table indicates its group number.
- The group number is assigned on the basis of valence shell electrons.

Example

- Group 1 has only 1 electron in its valence shell.
- Group 17 has 7 electrons in its valence shell.
- Mode of reaction of an atom depends upon its number of valence shell electrons.

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Q. No. 2 Define the Chemical bond. Explain octet rule.

4.2 CHEMICAL BOND

Definition

The force of attraction between atoms that holds them together in a molecule. During bond formation there is some force which holds the atoms together.

Octet rule

The attaining of 8 electron configuration in the outermost shell either by sharing, by losing or by gaining electrons, is called octet rule.

- This octet rule only symbolizes that noble gas electronic configuration should be attained by atoms when they combine or react.
- For elements like hydrogen or helium; which have only s-sub shell, this becomes "duplet rule".
- It plays a significant role in understanding the formation of chemical bond between atoms.

Explanation

If the bond formation is between ions, it is due to an electrostatic force between them. But if bond formation is between similar atoms or between the atoms that have comparable electro negativities, then the chemical bond formation is by 'sharing' of electrons. This sharing of electrons may be mutual or one sided.

Effect of repulsive forces on bond formation

When two approaching atoms come closer, the attractive as well as repulsive forces become operative. The formation of a chemical bond is a result of net attractive forces which dominate. The energy of that system is lowered and molecule is formed. Otherwise if repulsive forces become dominant no chemical bond will be formed. In that case there will be increase in the energy of the system due to creation of repulsive forces.

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4.3 TYPES OF CHEMICAL BOND

Bonding electrons

The valence electrons, which are involved in chemical bonding, are termed as bonding electrons. They usually reside in the incomplete or partially filled outermost shell of an atom.

There are four types of chemical bonds:

- Ionic Bond
- Covalent Bond
- Dative Covalent or Coordinate Covalent Bond
- Metallic Bond

Q. No. 3 Define the ionic bond. Explain ionic bond with the help of example

4.3.1 Ionic Bond

A Chemical bond which is formed due to complete transfer of electron from one atom to another atom is called ionic bond.

Explanation

The elements of Group-1 and Group-2 being metals have the tendency to lose their valence electrons forming positively charged ions. Whereas non-metals of Group-15 to Group-17 have tendency to gain or accept electrons. They are electronegative elements with high electron affinities. If atoms belonging to these two different groups, metals and non-metals, are allowed to react and chemical bond is formed.

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Properties

- It is to be noted that only valence shell electrons take part in this type of bonding.
- While other electrons are not involved.
- In such type of reaction heat is usually given out.
- The compounds formed due to this type of bonding are called ionic compounds.

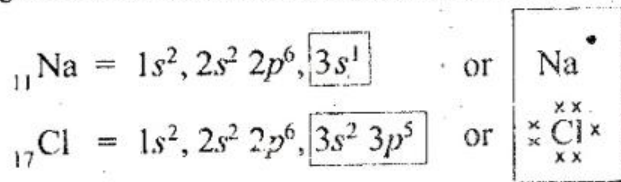
Example

The formation of NaCl is a good example of this type of bond.

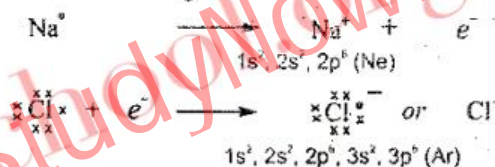
$$2Na_{(s)} + Cl_{2(g)} \longrightarrow 2NaCl_{(s)}$$

Sodium chloride is a simple compound formed from Sodium (Z=11) and Chlorine (Z= 17). The ground state electronic configuration of these elements is shown below:

$$_{11}Na = 1s^2, 2s^2\ 2p^6, \boxed{3s^1} \quad \text{or} \quad Na^{\bullet}$$

$$_{17}Cl = 1s^2, 2s^2\ 2p^6, \boxed{3s^2\ 3p^5} \quad \text{or} \quad \overset{\times\times}{\underset{\times\times}{\times Cl \times}}$$

The frame indicates electrons in valence shells of the elements; sodium has only one electron and chlorine has seven electrons. Sodium being electropositive element has the tendency to lose electron and chlorine being an electronegative element, has the tendency to gain electron. Therefore, they form positive and negative ions by losing and gaining electrons respectively, and their electronic configuration resembles with the nearest noble gases. $1S^2, 2S^2, 2p^6, 3s^2, 3p^6$ (Ar)

$$Na^{\bullet} \longrightarrow Na^+ + e^-$$
$$1s^2, 2s^2, 2p^6 \text{ (Ne)}$$

$$\overset{\times\times}{\underset{\times\times}{\times Cl \times}} + e^- \longrightarrow \left[\overset{\times\times}{\underset{\times\times}{\times Cl \bullet}}\right]^- \text{ or } Cl^-$$
$$1s^2, 2s^2, 2p^6, 3s^2, 3p^6 \text{ (Ar)}$$

Q. No. 4 Define the covalent bond. Explain the types of covalent bond.

4.3.2 COVALENT BOND

Definition

The type of bond, which is formed due to mutual sharing of electrons, is called covalent bond.

Explanation

The elements of Group-13 to Group-I when allowed to react with each other, they form a chemical bond by mutual sharing of their valence shell electrons. The energy changes during the covalent bond formation are of considerable value. When two atoms approach each other attractive forces develop between electrons of one atom and nucleus of other atom. Simultaneously repulsive forces between electrons of the two atoms as well as between their nuclei are also created. When the attractive forces dominate due to decrease in distance between those two atoms, a chemical bond is formed between them. By this mutual sharing of valence shell electrons each of the contributing atom attains the 'Octet' or nearest inert gas configuration

Bond pair

The covalent bond is formed by mutual sharing of electrons between two atoms. The electrons that pair up to form a chemical bond art called 'bond pair' electrons.

Examples

- Hydrogen chlorine
- Nitrogen
- Oxygen gases

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Types of covalent bonds

Depending upon the number of bond pairs, covalent bond is classified into following three types:

- Single Covalent bond.
- Double Covalent bond.
- Triple Covalent bond

Single Covalent Bond (–)

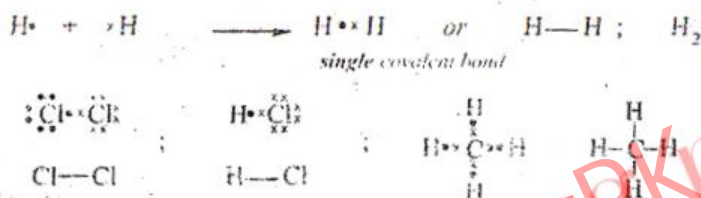
When one electron is contributed by each bonded atom, one bond pair is formed and it forms a single covalent bond.

Representation

While drawing the structure of molecules the single bond pair is indicated by a line between those two atoms.

$$H\cdot + {}_{\times}H \longrightarrow H{\cdot\times}H \quad or \quad H—H \; ; \quad H_2$$

single covalent bond

Cl—Cl ; H—Cl ; H–C–H

Example

- Hydrogen (H_2).
- Chlorine (Cl_2).
- Hydrochloric acid (HCl).
- Methane (CH_4).

Double Covalent Bond

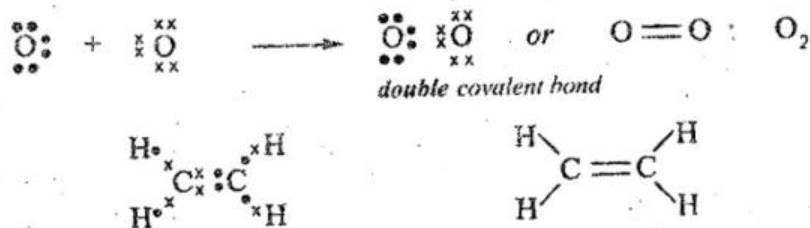
When each bonded atom contributes two electrons, two bond pairs are shared and a double covalent bond is formed.

Representation

These bond pairs are indicated as double line between those atoms in the structure of such molecules.

$$O + O \longrightarrow O::O \quad or \quad O=O \; ; \quad O_2$$

double covalent bond

H₂C=CH₂

Example

- Oxygen (O_2) gas.
- Ethane (C_2H_4).

Triple Covalent Bond (≡)

When each bonded atom contributes three electrons, three bond pairs are involved in bond formation. This type is called triple covalent bond.

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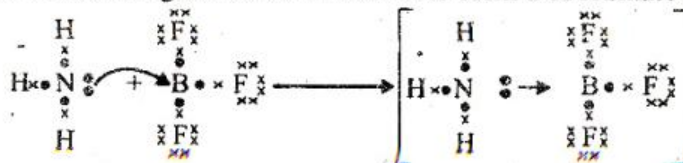
Formation of co ordinate covalent bond between ammonia and boron tri fluoride

In the formation of BF_3 (boron tri fluoride) molecule, three valence electrons of boron atom (Z= 5) pair up with three electrons, one from each three fluorine atoms. The boron atom even after this sharing of electrons (covalent bond formation), remains short or deficient of two electrons in its outermost shell. Now if a molecule with a lone pair approaches this molecule, it accepts lone pair from that donor and forms a coordinate covalent bond. The one pair on nitrogen of ammonia molecule makes it a good donor molecule to form a coordinate covalent bond.

Q. No. 6 Explain in detail the Polar and non polar Covalent bond.

4.3.4 POLAR AND NON-POLAR COVALENT BOND.

Non-Polar Covalent Bond

If a covalent bond is formed between two similar atoms (homo-atoms), shared pair of electrons is attracted by both the atoms equally. Such type of bond called non-polar covalent bond.

Explanation

These bonds are formed by equal sharing of electron pair between the two bonding atoms. This type of bond is called a pure covalent bond.

Example

Bond formation in H_2 and Cl_2

Polar Covalent Bond

The delta (δ) sign indicates partial positive or partial negative charge that is developed due to unequal sharing of shared pair or bonded pair of electrons. The compounds resulting from polar covalent bonds are called polar compounds.

Formation of polar bond

When there is difference of electro negativity between two covalently bonded atoms, there will be unequal attraction for the bond pair of electrons between such atoms. It will result in the formation of polar covalent bond.

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Polarity

The difference between electro negativities of hydrogen and chlorine is 1.0. As the electro-negativity of chlorine is more, it attracts the shared pair of electron towards itself with a greater force. A partial negative charge is therefore created on chlorine and in turn a partial positive charge on hydrogen due to electro negativity difference. It creates polarity in the bond and is called polar covalent bond.

- Water
- Hydrogen fluoride
- Hydrogen chloride

Nature of ionic bond

By using electro negativity values, it is possible to predict whether a chemical bond will be ionic or covalent in nature. A bond formed between elements of high electro negativity (halogen group) and elements of low electro negativity (alkali metals) are ionic in nature there is complete transfer of electrons between them.

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Range of electronegativity

If the difference of electro negativities between two elements is more than 1.7 the bond between them will be predominantly ionic bond and if it is less than 1.7, the bond between two atoms will be predominantly covalent.

Q. No. 7 Explain in detail Metallic bond. Give the reason for the formation of metallic bond in metals.

4.3.5 METALLIC BOND

Definition

The metallic bond is defined as a bond formed between metal atoms (positively charged ions) due to mobile or free electrons.

Properties

- They have high melting and boiling points.
- They show good conductions of heat and electricity.
- They are hard and heavy nature.

Reason for the formation of metallic bond in metals

- In case of metals, the hold of nucleus over the outermost electrons is weak because of large sized atoms and greater number of shells in between nucleus and valence electrons.
- Because of low ionization potentials, metals have the tendency to lose their outer electrons easily.
- The loose 'or free electrons of all metal atoms move freely in the spaces between atoms of a metal.
- None of these electrons is attached to any particular atom.
- They belong to a common pool or belong to all the atoms of that metal.
- Nuclei of metal atoms appear submerged in sea of these free mobile electrons.
- The mobile electrons are responsible for holding the atoms of metals together forming a metallic bond.

Example:

- Na
- Ca
- Mg

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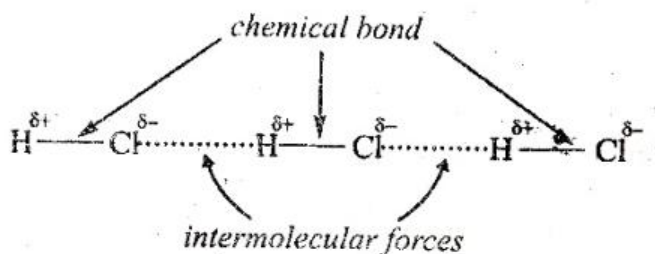
Q. No. 8 What is intermolecular forces. Explain its types in detail.

4.4 INTERMOLECULAR FORCES

Definition

The forces that hold atoms in a compound are chemical bonds. In addition to these strong bonding forces, relatively weak forces also exist in between the molecules, which are called intermolecular forces.

Types

- Dipole-dipole interaction
- Hydrogen bonding.

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Example

The bonding and intermolecular forces of hydrochloric acid

It requires about 17 kJ energy to break these intermolecular forces between one mole of liquid hydrogen chloride molecules to convert it into gas. Whereas, about 430 kJ are required to break the chemical bond between hydrogen and chlorine atoms in 1 mole of hydrogen chloride.

4.4.1 Dipole - Dipole Interaction

The forces of attraction between oppositely charged portions of two adjacent molecules. These attractive forces are called dipole -dipole interactions

Explanation

- All intermolecular forces, which are collectively called van der Waals forces, are electrical in nature.
- They result from the attractions of opposite charges which may be temporary or permanent.
- The unequal sharing of electrons between two different types of atoms make one end of molecule slightly positive and other end slightly negatively charged.
- As shared pair of electron is drawn towards more electronegative atom, it is partially negatively charged, as chlorine in hydrogen chloride. The other end automatically becomes partially positively charged.
- When partial positive and partial negative charges exist at different positions in a molecule, the adjacent molecules will arrange themselves in such a way that negative portion of that molecule comes near to positive portion of other molecule.

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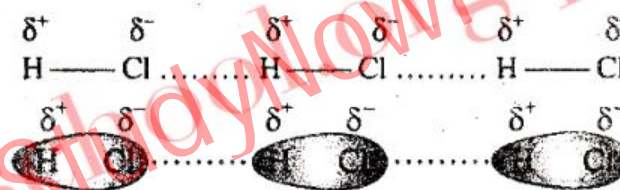
Q. No. 9 Explain the hydrogen bonding. Write down importance of hydrogen bonding.

4.4.2 Hydrogen Bonding

Partially positively hydrogen of one molecule attracts and forms a bond with the partially negatively charge atom of the other molecule, the bonding is called hydrogen bonding

Explanation

Hydrogen bonding is a special type of intermolecular forces present in the permanently polar molecules. This bonding can be considered unique dipole-dipole attraction. This force of attraction develops between molecules that have a hydrogen atom bonded to a small, highly electronegative atom with lone pairs-of electrons such as nitrogen, oxygen and fluorine. The covalent bond between hydrogen atom and other atom becomes polar enough to create a partial positive charge on hydrogen atom and a partial negative charge on the other atom. The small size and high partial positive charge on the hydrogen atom enables it to attract highly electronegative (N,O or F) atom of the other molecule.

This force of attraction is represented by a dotted line between the molecules as shown below:

Hydrogen bonding affects the physical properties of the molecules.

- Due to this boiling points of the compounds are affected greatly.
- It enhances the force of attraction between molecules.

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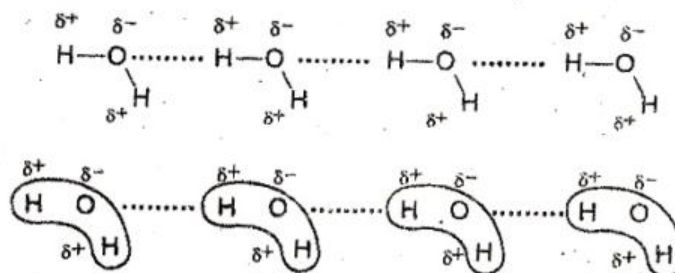
Example

Boiling point of water (100 °C) is higher than that of alcohol (78°C) because of more and stronger hydrogen bonding in water.

$\overset{\delta+}{H}-\overset{\delta-}{O}\cdots\cdots \overset{\delta+}{H}-\overset{\delta-}{O}\cdots\cdots \overset{\delta+}{H}-\overset{\delta-}{O}\cdots\cdots \overset{\delta+}{H}-\overset{\delta-}{O}$ (each O also bonded to $\overset{\delta+}{H}$)

Importance of Hydrogen bonding

The important phenomenon of floating of ice over water is because of hydrogen bonding. The density of ice at 0 ^{0}C (0.917 gcm^{-3}) is less than that of liquid water at 0 °C (1.00 gcm^{-3}). In the liquid state water molecules move randomly, however. When water freezes the molecules arrange themselves in an ordered form that gives them open structure. This process expands the molecules. That results in ice being less dense as compared to water.

4.5 NATURE OF BONDING AND PROPERTIES

Properties of the compounds depend upon the nature of bonding present in them. Let us discuss the effects of nature of bonding on the properties of compounds.

Q. No. 10 Write down the properties of ionic compounds.

4.5.1 Ionic Compounds

Ionic compounds are made up of positively and negatively charged ions.

Explanation

Thus they consist of ions and not the molecules. These positively and negatively charged, ions are held together in a solid or crystal form with strong electrostatic attractive forces

Example

The orderly arrangement of Na+ and Cl^{-1} ions in a solid crystal of sodium Chloride

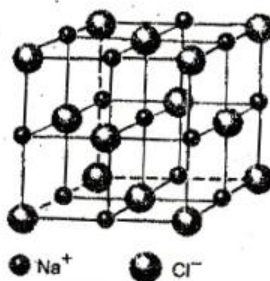



Figure 4.3 Regular arrangement of Na^+ and Cl^- ions in solid crystal of NaCl

Properties

The ionic compounds have following properties:

- Ionic compounds are mostly crystalline solids.
- Ionic compounds in solid state have negligible electrical conductance but they are good conductors in solution and in the molten form. It is due to presence of free ions in them.

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- Ionic compounds have high melting and boiling points. For example, sodium chloride has melting point 880°C and a boiling point 1413 °C. As ionic compounds are made up of positive and negative ions, there exist strong electrostatic forces of attraction between oppositely charged ions. So, a great amount of energy is required to break these forces.
- They dissolve easily in polar solvents like water. Water has high dielectric constant that weakens the attraction between ions.

Q. No. 11 Write down the properties of covalent compounds.

4.5.2 Covalent Compounds

The covalent compounds are made up of molecules that are formed by sharing of electrons between their atoms.

Explanation

Covalent bond is generally regarded as weaker than an ionic bond. Covalent compounds are made up of two or more non-metals Lower molecular mass covalent compounds are gases or low boiling liquid. Contrary to it, higher molecular mass covalent compounds are solids.

Example

- H_2
- Cl_2
- CO_2
- H_2O
- $C_6H_{12}O_6$

Properties

- They have usually low melting and boiling points.
- They are usually bad conductors of electricity.
- The compounds having polar character in their bonding are conductor of electricity when they dissolve in polar solvents.
- They are usually insoluble in water but are soluble in non-aqueous solvents like benzene, ether, alcohol and acetone.
- Bigger molecules with three dimensional bonding form covalent crystals which are very stable and hard.
- They have high melting and boiling points.

Q. No. 12 Write down the properties of polar and non-polar compounds.

4.5.3 Polar and Non-Polar Compounds

(i) Polar Compound

Polarity in a chemical bond is due to difference in electro negativities of the bonding atom.

Scale

On the Pauling Scale fluorine has been given an electronegativity value of 4.0. The values for other elements are calculated relative to it.

Properties

- Properties of non-polar and polar covalent compounds differ to some extent.
- While polar covalent compounds usually dissolve in water.
- Aqueous solution of a polar compound usually conducts electricity due to the formation of ions as a result of its reaction with water.

$$H\bullet + {}^{\times}_{\times}\ddot{\underset{\times\times}{Cl}}{}^{\times}_{\times} \longrightarrow \overset{\delta^+}{H} \bullet\times \overset{\delta^-}{Cl}$$

E.N. = 2.2   E.N. = 3.2

$\overset{\delta+}{H}$—$\overset{\delta-}{O}$—$\overset{\delta+}{H}$ $\overset{\delta+}{H}$—$\overset{\delta-}{F}$ $\overset{\delta+}{H}$—$\overset{\delta-}{Cl}$

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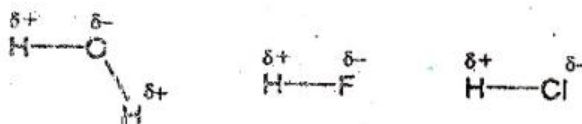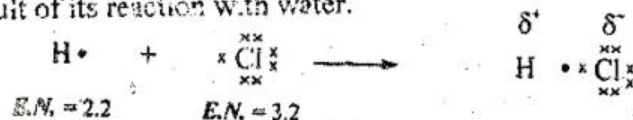
(ii) **Non-Polar Compound**

Definition

The compound which is formed by equal distribution of electrons shared pair.

Properties

- Non-polar covalent compounds usually do not dissolve in water
- Similarly non-polar compounds do not conduct electricity

Q. No. 13 Write down the properties of coordinate covalent compounds.

4.5.4 Coordinate Covalent Compounds

Properties

- Their properties are mostly similar to those of covalent compounds.
- As the nuclei in these compounds are held by shared electrons, therefore, they do not form ions in water.
- Due to their covalent nature they form solutions in organic solvents and are very less soluble in water.
- Usually they are rigid compounds with a dipole.

Q. No. 14 Write down the properties of metals.

4.5.4 Metals

Metals have common property of conducting heat and electricity. It give them prime role in many technologies.

Properties

- They show metallic luster.
- They are usually malleable and ductile. Malleability is the property by virtue of which a metal can be drawn into sheets, while ductility is the property by virtue of which a metal can be drawn into wires.
- They have usually high melting and boiling points.
- Being greater in size they have low ionization energies and form cations (M) very easily.
- They are good conductors of heat and electricity in solid and liquid state due to mobile electrons
- Metals have shining surface.
- They are good conductor of electricity.
- They are malleable and ductile.
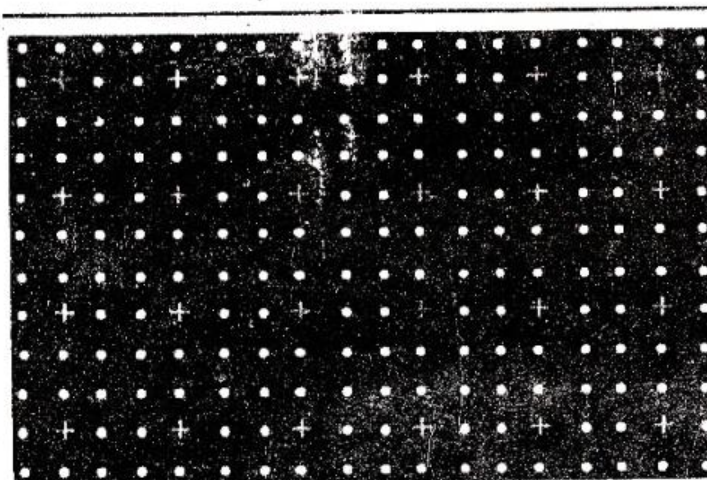
Fig. 4.2 A schematic diagram of Copper wire showing its positive nuclei (+) embedded in sea of free electrons (o) making 'Metallic Bonding'

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Q. No. 15 Write down the properties of synthetic adhesives.

SYNTHETIC ADHESIVES

Properties

- Although natural adhesives are less expensive to produce,
- but most important adhesives used nowadays are synthetic.
- Adhesives based on synthetic resins and rubbers excel in versatility and performance.
- Synthetics adhesives can be produced in a constant supply with uniform SCIECE properties and they can be modified in many ways.
- The polymers or resins used in synthetic adhesives fall into two general categories-thermoplastics and thermosetting.

Example

One form of polymer used industrially is epoxy adhesive.

Q. No. 16 Why epoxy adhesive is a best adhesive in the world?

AIR CRAFTS, CARS, TRUCKS AND BOATS ARE PARTIALLY HEW TOGETHER WITH EPOXY ADHESIVES

Definition

Epoxy is polymer that is formed from two different chemicals. These are referred to as resin and the hardener. Epoxy adhesives are called structural adhesives.

Uses

- These high-performance adhesives are used in the construction of aircraft, automobiles, bicycles, boats, golf clubs, where high strength bonds are required.
- Epoxy adhesives can be developed to suit almost any application.

Properties

- They can be made flexible or rigid, transparent or opaque even colored as well as fast or slow setting.
- Epoxy adhesives are good heat and chemical resistant
- They are stable to heat up to temperatures 177°C.
- Because of these properties, they are given the name of engineering adhesives.

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EXERCISE

MCQ'S

1. **Atoms react with each other because:**
   (a) they are attracted to each other. (b) they are short of electrons
   (c) they want to attain stability (d) they want to disperse
2. **An atom having six electrons in its valence shell will achieve noble gas electronic configuration by:**
   (a) gaining one electron (b) losing all electrons
   (c) gaining two electrons (d) losing two electrons
3. **Considering the electronic configuration of atoms which atom with the given atomic number will be the most stable one?**
   (a) 6 (b) 8 (c) 10 (d) 12
4. **Octet rule is:**
   (a) description of eight electrons (b) picture of electronic configuration
   (c) pattern of electronic configuration (d) attaining of eight electrons
5. **Transfer of electrons between atoms results in:**
   (a) metallic bonding (b) ionic bonding
   (c) covalent bonding (d) coordinate covalent bonding
6. **When an electronegative element combines with electropositive element the type of bonding is:**
   (a) covalent (b) ionic
   (c) polar covalent (d) coordinate covalent
7. **A bond formed between two non-metals is expected to be:**
   (a) covalent (b) ionic (c) coordinate covalent (d) metallic
8. **A bond pair in covalent molecules usually has:**
   (a) one electron (b) two electrons (c) three electrons (d) four electrons
9. **Which of the following compounds is not directional in its bonding?**
   (a) C (b) KBr (c) CO_2 (d). H_2O
10. **Ice floats on water because:**
    (a) ice is denser than water (c) water is denser than ice
    (b) ice is crystalline in nature (d) water molecules move randomly
11. **Covalent bond involves the**
    (a) donation of electrons (b) acceptance of electrons
    (c) sharing of electrons (d) repulsion of electrons

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12. **How many covalent bonds does C_2H_2 molecule have?**
(a) two (b) three (c) four (d) five

13. **Triple covalent bond involves how many number of electrons?**
(a) eight (b) six (c) four (d) only three

14. **Which pair of the molecules has same type of covalent bonds?**
(a) O_2 and HCl (b) O_2 and N_2 (c) O_2 and C_2 (d) O_2 and C_2H_2

15. **Identify the compound which is not soluble in water.**
(a) C_6H_6 (b) NaCl (c) KBr (d) $MgCl_2$

16. **Which one of the following is an electron deficient molecule?**
(a) NH_3 (b) BF_3 (c) N_2 (d) O_2

17. **Identify which pair has polar covalent bonds.**
(a) O_2 and Cl_2 (b) H_2O and N_2 (c) H_2O and C_2H_2 (d) H_2O and HCl

18. **Which one of the following is the weakest force among the atoms?**
(a) ionic force (b) metallic force (c) intermolecular force (d) covalent force

ANSWR KEY

1	c	4	d	7	a	10	c	13	b	16	b
2	c	5	b	8	b	11	c	14	d	17	d
3	c	6	b	9	b	12	d	15	a	18	c

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SHORT QUESTIONS

Q.1 Why do atoms react?

Ans: It is an universal rule that everything in this world tends to become more stable. Atoms achieve stability by attaining electronic configuration of inert gases (He, Ne or Ar etc.) having 2 or 8 electrons in the valence shell is sign of satiability. Attaining two electrons in the valence shell called duplet rule while attaining 8 electron in the valence shell is called octet rule.

Q.2 Why is the bond between an electropositive and an electronegative atom ionic in nature?

Ans: Because ionic bond is formed due to transfer of electron from one atom to another atom is called ionic bond. The elements of Group 1 and 2 being metals have the tendency to lose their electrons forming positively charged ions. Whereas non-metals of Group 15 Group 17 have the tendency to gain or accept electrons. They are electronegative elements with high electron affinities.

Q.3 Ionic compounds are solids. Justify.

Ans: Ionic compounds are made up of positively and negatively charged ions. Thus, they consist of ions and not molecules. These positively and negatively charged ions are held together in a solid or crystal form with strong electrostatic attractive forces. So, ionic compounds are solid in nature.

Q.4 More electronegative elements can form bonds between themselves. Justify.

Ans: Yes, more electronegative elements can form bonds between themselves. Because they have comparable electronegativity and form covalent bond between similar atoms called does diatoms.

For example: Formation of covalent bonds between two atoms of oxygen and chlorine etc.

Q.5 Metals are good conductor of electricity. Why?

Ans: Metals are good conductors of electricity because metals have free electrons which are mobile in nature. Spaces are present among the atoms. Mobile electron can move freely in these spaces. Hence, movement or flow of electron is known as electricity that's why metals are good conductor of electricity.

Q.6 Ionic compounds conduct electricity in solution or molten form. Why?

Ans: Ionic compounds conduct electricity in solution or molten form because in these tow states ionic compounds have free in them. When these free ions move in solution or molten state they become conductor of electricity.

Q.7 What type of covalent bond is formed in nitrogen molecule?

Ans: In nitrogen molecule, three bond pairs are involved in bond formation. This type is called triple covalent bond. Three small lines are used to indicate these three pairs of electrons between those atoms in the molecules of such compounds.

$$\ddot{N} \equiv \ddot{N}$$

Q.8 Differentiate between lone pair and bond pair of electron.

Ans:

Lone pair	Bond pair
The non-bonded electron pair available on an atom, like the one lone pair is available on nitrogen in ammonia is called a pair e.g, NH_3	The bonded electron pair available present within the atoms is called a bond pair e.g. H ÷ Cl.

Q.9

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Q.10 Describe at least two necessary conditions for the formation of a covalent bond.

Ans: Two necessary conditions for the formation of covalent bond are:

- The electronegativity difference between atoms must be less. So, that the shared pair of electrons is attracted by both the atoms equally.
- Maximum 3 to 6 electron are present in their valence shells.

Example: HCl, Cl_2, C_6H_6 and C_2H_2

Q.11 Why HCl has dipole-dipole forces of attraction?

Ans: HCl has dipole-dipole forces of attraction. The unequal sharing of slightly positive and other end slightly negatively charged. As shared pair of electron is drawn towards more electronegative atom, it is partially negatively charged, as chlorine in hydrogen chloride. The other end automatically becomes partially positively charged.

$$H^{\delta+} — Cl^{\delta-}$$

Q.12 What is a triple covalent bond, explain with an example?

Ans: When each bonded atom contributes three electrons, three bond pairs are involved in bond formation. This type is called triple covalent bond. Three small lines are used to indicate these three pairs of electrons between those atoms in the molecules of such compounds.

For example:

- N_2
- C_2H_2

Q.13 What is difference between polar and non-polar covalent bonds, explain with one example of each?

Ans:

Polar covalent bonds	Non-polar covalent bonds
If the covalent bond is formed between two different types of atoms then bond pair of electrons will not be attracted equally y the bonded atoms. One of the atoms will attract the bond pair of electrons more strongly than the other one. They form polar covalent bond. **For example:** HCl and H_2O	If a covalent bond is formed between two similar atoms, the shared pair of electrons is attracted by both the atoms equally. Such type of covalent bond is called non-polar covalent bond. **For example:** H_2 and Cl_2

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Q.14 Why a covalent bond becomes polar?

Ans: When there is a difference of electronegativity between two covalently bonded atoms, there will be unequal attraction for the bond pair of electrons between such atoms. It will result in the formation of polar covalent bond.

Example: HCl, H_2O

Q.15 What is relationship between electronegativity and polarity?

Ans: Electronegativity values of the atoms play a very important role in polarity of compounds. These two terms have direct relationship with one another, because of electronegativity difference is high then more polar bond will be and vice versa.

Example:

$$\overset{\delta+}{H}—\overset{\delta-}{O}—\overset{\delta+}{H} \qquad \overset{\delta+}{H}—\overset{\delta-}{F} \qquad \overset{\delta+}{H}—\overset{\delta-}{Cl}$$

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Q.16 Why does ice float on water?

Ans: Floating of ice on water is because of hydrogen bonding. The density of ice at $0^{\circ}C$ (0.917 g/cm^3) is less than that of liquid water at $0^{\circ}C$ (1.00 gcm^{-3}). In the liquid state water molecules move randomly. However, water freezes, the molecules arrange themselves in an ordered form that gives them open structure. This process expands the molecules that results in ice being less dense as compared to water.

Q.17 Give the characteristic properties of ionic compounds.

Ans: Ionic compound are mostly crystalline solids.

- Ionic compounds in solid state have negligible electrical conductance but they are good conductors in solution and n the molten form. It is due to presence of free ions in them.
- Ionic compounds have high melting and boiling points. For example NaCl has M.P $800^{0}C$ and B.P. $1413^{0}C$.
- Ionic compounds dissolves in polar solvents. Like NaCl dissolves in water.

Q.18 What characteristic properties do the covalent compound have?

Ans:

- They have usually low melting and boiling point.
- They are usually bad conductors of electricity.
- They are usually insoluble in water.
- Bigger molecules with three dimensional bonding form covalent crystals which are very stable and hard. They have high melting and boiling points.

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LONG QUESTIONS

Q.1 What is an ionic bond? Discuss the formation of ionic bond between sodium and chlorine atoms?

Ans: See the topic Ionic bond

Q.2 How can you justify that bond strength in polar covalent compounds is comparable to that of ionic compound?

Ans: See the topic strength of polar covalent bond

Q.3 What type of covalent bonds are formed between hydrogen, oxygen and nitrogen? Explain their bonding with dot and cross model.

Ans: See the topic Lewis dot diagram

Q.4 How a covalent bond develops ionic character in it? Explain.

Ans: See the topic Polar covalent bond

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Q.5 Explain the types of covalent bonds with at least one example of each type.

Ans: See the topic types of covalent bonds

Q.6 How a coordinate covalent bond is formed? Explain with examples?

Ans: See the topic dative covalent bond

Q.7 What is metallic bonds? Explain the metallic bonding with the help of a di

Ans: See the topic metallic bonding

Q.8 Define hydrogen bonding. Explain that how these forces affect the physical properties of compounds.

Ans: See the topic hydrogen bonding

Q.9 What are intermolecular forces? Compare these forces with chemical bond forces with reference to HCl molecule?

Ans: See the topic intermolecular forces

Q.10 What is a chemical bond and why do atoms form a chemical bond?

Ans: See the topic introduction of chemical bond

Q.11 What is octet rule? Why do atoms always struggle to attaint he nearest noble gas electronic configuration?

Ans: See the topic introduction of chemical bonding.

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CHAPTER

STRUCTURE OF MOLECULES

MULTIPLE CHOICE QUESTIONS

1. Elements of group 18 are called:
(a) noble metals (b) noble gases (c) noble (d) none of these

2. Element attaining eight electrons in its outermost shell are called
(a) duplet rule (b) octet rule (c) both "a" and "b" (d) none of these

3. The force of attraction which holds the atom together is called
(a) ionic bond (b) covalent bond (c) hydrogen bond (d) chemical bond

4. Every atom tries to attain
(a) maximum energy (b) stable energy (c) minimum energy (d) covalent energy

5. Which force of attraction is present between positive and negative ions?
(a) homolytic (b) electrostatic (c) electro elastic (d) electronic

6. A bond formed by the complete transfer of electron from one atom to other is called
(a) chemical bond (b) covalent bond (c) ionic bond (d) metallic bond

7. Hydrogen acquires the electronic configuration like
(a)Xe (b) Ne (c) He (d) Ar

8. In non polar covalent bond the bonded atoms share the electrons
(a) not equally (b) equally (c) differently (d) oppositly

9. In polar covalent bonds molecules are
(a) homo atomic (b) tri atomic (c) hetero atomic (d) mono atomic

10. Dipole-dipole interactions are
(a) magnetic (b) electric (c) neutral (d) stable

11. Energy requires to break forces of one mole liquid HCl molecule is
(a) 16kJ (b) 15kJ (c) 17kJ (d) 18kJ

12. The density of ice at 0°C is
(a) 0.917 gcm^{-3} (b) 0.719 gcm^{-3} (c) 0.197 gcm^{-3} (d) 0.0917 gcm^{-3}

13. One form of polymer used industrially as a adhesive
(a) epoxy (b) explosive (c) synthetic (d) natural

14. Epoxy is a polymer formed by the resin and
(a) shiner (b) softener (c) hardener (d) thiner

15. Substance have the tendency to gain electrons and anions
(a) metals (b) non metals (c) metalloids (d) halogens

16. Which properties are affected by hydrogen bonding
(a) physical (b) chemical (c) ionic (d) metallic

17. Which scientist had given the idea of octaves in periodic table?
(a) Mendeleev (b) Al-razi (c) Newland (d) Dobereiner

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ANSWER KEY

1	b	4	c	7	c	10	c	13	a	16	a
2	b	5	b	8	b	11	c	14	d	17	c
3	d	6	c	9	c	12	a	15	d	KIPS	

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SHORT QUESTIONS

4.3 TYPES OF CHEMICAL BONDS

Q.1 Why does sodium form a chemical bond with chlorine?

Ans. Sodium form chemical bond with chlorine because, sodium has only one electron in its valence shell while, chlorine has seven electron in its valence. Sodium is electropositive in nature, so by losing its valence electron, it attains noble gas electronic configuration while chlorine is electronegative in nature gain an electron to become stable.

Q.2 Why does sodium lose an electron and attains +1 charge?

Ans. Sodium is electropositive in nature, it easily loss its valence shell to attain its stability and electronic configuration like noble gas helium.

$$Na_{11} \xrightarrow{loss\ one\ electron} Na^{+} + 1e^{-}$$
$$(2,8,1) \qquad\qquad (2,8)$$

Q.3 How do atoms follow octet rule?

Ans. To attain 8 electron configuration in the outermost shell either by losing, gaining or sharing electrons, is called octet.

So all atoms except hydrogen and helium obey octet rule to attain electronic configuration and stability like noble gas (Ne, Ar, etc)

Q.4 Which electrons are involved in chemical bonding?

Ans. Only valence shell electrons are involved in chemical bonding.

Q.5 Why does group 1 elements prefer to combine with group 17 elements.

Ans. Because, all the elements of group I have one electron in their valenece shell. They are electropositive in nature and lose their outermost electron easily. That one loosed electron easily gained by the elements of 17^{th} group that require only one electron to attain configuration like noble gases.

Q.6 Why chlorine can accept only 1 electron?

Ans. Chlorine have seven electrons in its outermost shell as:

It requires only one electron to complete its valence shell, electronic configuration like Argon (Ar_{18}). So, it gains one electron from the elements of 1^{st} group mostly.

Q.7 Give the electronic configuration of carbon atom.

Ans. The electronic configuration of carbon is $_{6}C = 1s^2, 2s^2, 2p^2$

Q.8 What type of elements have tendency of sharing of electrons?

Ans. The elements with low electronegativity values have the tendency to form covalent bonds. The elements of group 13 to group 17 usually form bonds of sharing of electrons. Because, they have three to six electrons in their valence shells. This electronic configuration is good to make covalent bonds.

Q.9 If repulsive forces dominate, attractive forces will a covalent bond be formed?

Ans. No, there will not be covalent bond formation if repulsive forces dominate to attractive forces. Because, the bond formation takes place when the attractive forces dominate due to decrease in distance between those two of atoms.

Q.10 Considering the electronic configuration of nitrogen atom, how many electrons are involved in bond formation and what type of covalent bond is test yourself formed.

Ans. Electronic configuration of nitrogen is $_{7}N = 1s^2, 2s^2, 2p^3$

So, three electrons are involved in bond formation of nitrogen atom. As shown in equation: $:\dot{N}\!: + \overset{\times}{\underset{\times}{\times}}N\overset{\times}{\times} \longrightarrow :N\!:\overset{\times}{\underset{\times}{\times}}N\overset{\times}{\times}$

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Q.11 Point out the type of covalent bonds in the following molecules
CH_4, C_2H_4, H_2, N_2, and O_2

Ans.

Single covalent bond	Double Covalent Bond	Triple Covalent Bond
CH_4 or H–C–H (with H above and below C); H_2 or H – H	O_2 or O = O; C_2H_4 or $H_2C = CH_2$	N_2 or N≡N

Q.12 What is a lone pair? How many lone pairs of electrons are present on nitrogen in ammonia?

Ans. Lone pair: the non-bonded electron pair available on an atom, like the one lone pair is available on nitrogen in ammonia is called a lone-pair. There is one lone pair of electrons in ammonia molecule on nitrogen. Lone pair $\longrightarrow$ $:NH_3$

Q.13 Why is the BF_3 electron deficient?

Ans. In the formation of BF_3 molecule, three valence electrons of boron atom (Z=5) pair up with three electrons, "one form each three fluorine atoms". The boron atom even after this sharing of electrons, remain short or deficient of two electrons in its outermost shell. If a molecule with a lone pair approaches this molecule, it accepts lone pair from that donor and forms a coordinate covalent bond.

Q.14 What types of electron pairs make a molecule good donor?

Ans. Lone pairs present on any atom make a molecule good donor. As in the case of ammonia molecule the lone pair present on nitrogen atom makes it good donor molecule to form a coordinate covalent bond.

Q.15 What is difference between bonded and lone pair of electron 'and how many bonded pair of electrons is present is NH_3 molecule?

Ans. Bonded pair of electrons are those electron pair which take part in chemical bonding. They occupy less space within the molecules than lone pairs. There are one lone pair present on a nitrogen atom in ammonia molecule. $\ddot{N}H_3$

Q.16 What do you mean by delta sign and why it develops?

Ans. The delta (δ) sign indicates partial positive or partial negative charge that is developed due to unequal sharing of shared pair or bonded pair of electrons. For Example: (δ) Delta signs in $H^{\delta+} - F^{\delta-}$ an[illegible] $^{\delta+} - Cl^{\delta-}$ shows the partial charges of these molecules.

Q.17 Why does oxygen molecule not form a polar covalent bond?

Ans. Oxygen molecule does not form a polar covalent bond because there is no electronegativity difference between oxygen atoms. Oxygen atom has six valence electrons. It requires two electrons to attain nearest noble gas electronic configuration of $_{10}Ne$.

Q.18 Why has water polar covalent bonds?

Ans. Water formed by the combination of oxygen and hydrogen atoms. The electro-negativity difference between oxygen and hydrogen atoms is maximum. When the electro-negativity difference between two covalently bonded atoms, there will be unequal attraction for the bond pair of electrons between such atoms. Due to this reason, water is polar covalent bond.

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Q.19 What type of elements form metallic bonds?

Ans. Metals form metallic bonds in them. Because metal atoms are positively charged atoms which have mobile or free electron in them.

Example: (i) Sodium Atom have one mobile electron.
(ii) Calcium atom have two mobile electron.

Q.20 Why is the hold of nucleus over the outermost electrons in metals weak?

Ans. The hold of nucleus over the outermost electrons is weak because of large sized atoms and greater number of shells in between nucleus and valence electrons because of shielding effect.

Example: Sodium required more energy to lose outer most electron then potassium.

Q.21 Why the electrons move freely in metals?

Ans. Metals have low ionization potentials hence metals have the tendency to lose their outer electrons easily. Resultantly, these lose or free electrons of all metal atoms move freely in the spaces between atoms of a metal. None of these electrons is attached to any particular atoms. Nuclei of metal

Q.22 Which types of electrons are responsible for holdings the atoms together in metals?

Ans. Mobile electrons present within the metals are responsible for holding the atoms of metals together forming a metallic bond. Metals have the tendency to loose their electrons, these electrons are known as mobile electrons.

4.4 INTERMOLECULAR FORCES

Q.1 Define intermolecular forces; show these forces among HCl molecule.

Ans. Intermolecular forces are those forces which are relatively weak forces also exist in between the molecules. These forces are shown in hydrogen chloride molecule.

Q.2 Why a dipole develops in a molecule?

Ans. Dipole develops in a molecule as a result from the attractions of opposite charges which may be temporary or permanent. The unequal sharing of electrons between two different types of atoms make one end of molecule slightly negatively charged due to difference in electronegativity.

For example: $H^{\delta+}$—$Cl^{\delta-}$------ $H^{\delta+}$—$Cl^{\delta-}$------ $H^{\delta+}$—$Cl^{\delta-}$

Q.3 What do you mean by induced dipole?

Ans. Induced Dipole: When partial positive and partial negative charges exist at different positions in a molecule, the adjacent molecules with arrange themselves in such a way that negative portion of that molecules come near to positive portion of other molecule. It results in a net forces of attraction between oppositely charged portions of two adjacent molecules.

For example: $H^{\delta+}$—$Cl^{\delta-}$------ $H^{\delta+}$—$Cl^{\delta-}$

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Q.4 Why are dipole forces of attraction not found in halogen molecules?

Ans. Intermolecular forces exist between the HCl molecules. These intermolecular forces are known as dipole-dipole forces. Because Halogens form diatom which are similar and having no electronegitivity difference that's why they don't have dipole–dipole interaction.

Example: Cl_2, I_2, Br_2 and F_2

Q.5 What types of attractive forces exist between HCl molecules?

Ans. Intermolecular forces exist between the HCl molecules. These intermolecular forces are known as dipole – dipole forces. Hydrogen have less electronegativity then chlorine so chlorine attracts share pair electron towards itself and acquire small negative charge and hydrogen acquire small positive charge. That's why dipole – dipole interaction develop between HCl molecules.

Example: $H^{\delta+}$ — $Cl^{\delta-}$ ------ $H^{\delta+}$ — $Cl^{\delta-}$

4.5 NATURE OF BONDING AND PROPERTIES

Q.1 Why the ionic compounds have high melting and boiling points?

Ans. Ionic compounds have high melting and boiling points. For Example, sodium chloride had melting point 800°C and a boiling point 1413°C. As ionic compounds are made up of positive and negative ions, there exist strong electrostatic forces of attraction between oppositely charged ions. So, a great amount of energy to break these forces.

Q.2 What do you mean by malleability?

Ans. Malleability is a special property of metals. By virtue of this property metal can be drawn into sheets

Example: Silvers can be convert into foils or sheets by applying pressure.

Q.3 Why are ionic compounds easily soluble in water?

Ans. Ionic compounds are easily soluble in water. Because water is a polar solvent. Water has high dielectric constant that weakens the attraction between ions.

Example: Sodium chloride can easily soluble in water.

Q.4 What type of bond exists in ionic compounds?

Ans. Ionic bond exist in ionic compounds which is formed by the complete transfer of electrons among different atoms.

Example: $BaCl_2$ having ionic bond in which Barium is cation and chloride is anoin.

Q.5 Why the covalent compounds of bigger size molecules have high melting points?

Ans. Bigger size covalent molecules have three dimensional bonding in them, which form covalent crystals which are very stable and hard. So, they have high melting and boiling points.

Example: Diamond, Graphite, Buck balls

Q.6 How much there is electronegativity difference between the following pair or elements (atoms). Predict the nature of the bond between them?

(a) Hand Cl **(b) Hand Na** **(c) Na and I** **(d) KandCl**

Ans.

Air of Elements	Electronegativity differences	Nature of bond
(a) H and Cl	0.9	Polar covalent bond
(b) H and Na	1.2	Ionic bond
(c) Na and I	1.6	Ionic bond
(d) K and Cl	2.2	Ionic bond

Q.7 Comparing the electronegativity differences, arrange these compounds in increasing ionic strength.

Ans. $0.9 < 1.2 < 1.6 < 2.2$

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EXERCISE

MCQ'S

1. **Atoms react with each other because:**
   (a) they are attracted to each other.
   (b) they are short of electrons
   (c) they want to attain stability
   (d) they want to disperse
2. **An atom having six electrons in its valence shell will achieve noble gas electronic configuration by:**
   (a) gaining one electron
   (b) losing all electrons
   (c) gaining two electrons
   (d) losing two electrons
3. **Considering the electronic configuration of atoms which atom with the given atomic number will be the most stable one?**
   (a) 6 (b) 8 (c) 10 (d) 12
4. **Octet rule is:**
   (a) description of eight electrons
   (b) picture of electronic configuration
   (c) pattern of electronic configuration
   (d) attaining of eight electrons
5. **Transfer of electrons between atoms results in:**
   (a) metallic bonding
   (b) ionic bonding
   (c) covalent bonding
   (d) coordinate covalent bonding
6. **When an electronegative element combines with electropositive element the type of bonding is:**
   (a) covalent
   (b) ionic
   (c) polar covalent
   (d) coordinate covalent
7. **A bond formed between two non-metals is expected to be:**
   (a) covalent (b) ionic (c) coordinate covalent (d) metallic
8. **A bond pair in covalent molecules usually has:**
   (a) one electron (b) two electrons (c) three electrons (d) four electrons
9. **Which of the following compounds is not directional in its bonding?**
   (a) C (b) KBr (c) CO_2 (d). H_2O
10. **Ice floats on water because:**
    (a) ice is denser than water
    (c) water is denser than ice
    (b) ice is crystalline in nature
    (d) water molecules move randomly
11. **Covalent bond involves the**
    (a) donation of electrons
    (b) acceptance of electrons
    (c) sharing of electrons
    (d) repulsion of electrons

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12. **How many covalent bonds does C_2H_2 molecule have?**

(a) two (b) three (c) four (d) five

13. **Triple covalent bond involves how many number of electrons?**

(a) eight (b) six (c) four (d) only three

14. **Which pair of the molecules has same type of covalent bonds?**

(a) O_2 and HCl (b) O_2 and N_2 (c) O_2 and C_2 (d) O_2 and C_2H_2

15. **Identify the compound which is not soluble in water.**

(a) C_6H_6 (b) NaCl (c) KBr (d) $MgCl_2$

16. **Which one of the following is an electron deficient molecule?**

(a) NH_3 (b) BF_3 (c) N_2 (d) O_2

17. **Identify which pair has polar covalent bonds.**

(a) O_2 and Cl_2 (b) H_2O and N_2 (c) H_2O and C_2H_2 (d) H_2O and HCl

18. **Which one of the following is the weakest force among the atoms?**

(a) ionic force (b) metallic force (c) intermolecular force (d) covalent force

ANSWR KEY

1	c	4	d	7	a	10	c	13	b	16	b
2	c	5	b	8	b	11	c	14	d	17	d
3	c	6	b	9	b	12	d	15	a	18	c

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SHORT QUESTIONS

Q.1 Why do atoms react?

Ans: It is an universal rule that everything in this world tends to become more stable. Atoms achieve stability by attaining electronic configuration of inert gases (He, Ne or Ar etc.) having 2 or 8 electrons in the valence shell is sign of satiability. Attaining two electrons in the valence shell called duplet rule while attaining 8 electron in the valence shell is called octet rule.

Q.2 Why is the bond between an electropositive and an electronegative atom ionic in nature?

Ans: Because ionic bond is formed due to transfer of electron from one atom to another atom is called ionic bond. The elements of Group 1 and 2 being metals have the tendency to lose their electrons forming positively charged ions. Whereas non-metals of Group 15 Group 17 have the tendency to gain or accept electrons. They are electronegative elements with high electron affinities.

Q.3 Ionic compounds are solids. Justify.

Ans: Ionic compounds are made up of positively and negatively charged ions. Thus, they consist of ions and not molecules. These positively and negatively charged ions are held together in a solid or crystal form with strong electrostatic attractive forces. So, ionic compounds are solid in nature.

Q.4 More electronegative elements can form bonds between themselves. Justify.

Ans: Yes, more electronegative elements can form bonds between themselves. Because they have comparable electronegativity and form covalent bond between similar atoms called does diatoms.

For example: Formation of covalent bonds between two atoms of oxygen and chlorine etc.

Q.5 Metals are good conductor of electricity. Why?

Ans: Metals are good conductors of electricity because metals have free electrons which are mobile in nature. Spaces are present among the atoms. Mobile electron can move freely in these spaces. Hence, movement or flow of electron is known as electricity that's why metals are good conductor of electricity.

Q.6 Ionic compounds conduct electricity in solution or molten form. Why?

Ans: Ionic compounds conduct electricity in solution or molten form because in these tow states ionic compounds have free in them. When these free ions move in solution or molten state they become conductor of electricity.

Q.7 What type of covalent bond is formed in nitrogen molecule?

Ans: In nitrogen molecule, three bond pairs are involved in bond formation. This type is called triple covalent bond. Three small lines are used to indicate these three pairs of electrons between those atoms in the molecules of such compounds.

$$\ddot{N} \equiv \ddot{N}$$

Q.8 Differentiate between lone pair and bond pair of electron.

Ans:

Lone pair	Bond pair
The non-bonded electron pair available on an atom, like the one lone pair is available on nitrogen in ammonia is called a pair e.g, NH_3	The bonded electron pair available present within the atoms is called a bond pair e.g. H ÷ Cl.

Q.9

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Q.10 Describe at least two necessary conditions for the formation of a covalent bond.

Ans: Two necessary conditions for the formation of covalent bond are:

- The electronegativity difference between atoms must be less. So, that the shared pair of electrons is attracted by both the atoms equally.
- Maximum 3 to 6 electron are present in their valence shells.

Example: HCl, Cl_2, C_6H_6 and C_2H_2

Q.11 Why HCl has dipole-dipole forces of attraction?

Ans: HCl has dipole-dipole forces of attraction. The unequal sharing of slightly positive and other end slightly negatively charged. As shared pair of electron is drawn towards more electronegative atom, it is partially negatively charged, as chlorine in hydrogen chloride. The other end automatically becomes partially positively charged.

$$H^{\delta+} — Cl^{\delta-}$$

Q.12 What is a triple covalent bond, explain with an example?

Ans: When each bonded atom contributes three electrons, three bond pairs are involved in bond formation. This type is called triple covalent bond. Three small lines are used to indicate these three pairs of electrons between those atoms in the molecules of such compounds.

For example:

- N_2
- C_2H_2

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Q.13 What is difference between polar and non-polar covalent bonds, explain with one example of each?

Ans:

Polar covalent bonds	Non-polar covalent bonds
If the covalent bond is formed between two different types of atoms then bond pair of electrons will not be attracted equally y the bonded atoms. One of the atoms will attract the bond pair of electrons more strongly than the other one. They form polar covalent bond. **For example:** HCl and H_2O	If a covalent bond is formed between two similar atoms, the shared pair of electrons is attracted by both the atoms equally. Such type of covalent bond is called non-polar covalent bond. **For example:** H_2 and Cl_2

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Q.14 Why a covalent bond becomes polar?

Ans: When there is a difference of electronegativity between two covalently bonded atoms, there will be unequal attraction for the bond pair of electrons between such atoms. It will result in the formation of polar covalent bond.

Example: HCl, H_2O

Q.15 What is relationship between electronegativity and polarity?

Ans: Electronegativity values of the atoms play a very important role in polarity of compounds. These two terms have direct relationship with one another, because of electronegativity difference is high then more polar bond will be and vice versa.

Example:

$H^{\delta+}—O^{\delta-}—H^{\delta+}$ $H^{\delta+}—F^{\delta-}$ $H^{\delta+}—Cl^{\delta-}$

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Q.16 Why does ice float on water?

Ans: Floating of ice on water is because of hydrogen bonding. The density of ice at 0^oC (0.917 g/cm^3) is less than that of liquid water at 0^oC (1.00 gcm^{-3}). In the liquid state water molecules move randomly. However, water freezes, the molecules arrange themselves in an ordered form that gives them open structure. This process expands the molecules that results in ice being less dense as compared to water.

Q.17 Give the characteristic properties of ionic compounds.

Ans: Ionic compound are mostly crystalline solids.

- Ionic compounds in solid state have negligible electrical conductance but they are good conductors in solution and n the molten form. It is due to presence of free ions in them.
- Ionic compounds have high melting and boiling points. For example NaCl has M.P 800^0C and B.P. 1413^0C.
- Ionic compounds dissolves in polar solvents. Like NaCl dissolves in water.

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Q.18 What characteristic properties do the covalent compound have?

Ans:

- They have usually low melting and boiling point.
- They are usually bad conductors of electricity.
- They are usually insoluble in water.
- Bigger molecules with three dimensional bonding form covalent crystals which are very stable and hard. They have high melting and boiling points.

LONG QUESTIONS

Q.1 What is an ionic bond? Discuss the formation of ionic bond between sodium and chlorine atoms?

Ans: See the topic Ionic bond

Q.2 How can you justify that bond strength in polar covalent compounds is comparable to that of ionic compound?

Ans: See the topic strength of polar covalent bond

Q.3 What type of covalent bonds are formed between hydrogen, oxygen and nitrogen? Explain their bonding with dot and cross model.

Ans: See the topic Lewis dot diagram

Q.4 How a covalent bond develops ionic character in it? Explain.

Ans: See the topic Polar covalent bond

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Q.5 Explain the types of covalent bonds with at least one example of each type.

Ans: See the topic types of covalent bonds

Q.6 How a coordinate covalent bond is formed? Explain with examples?

Ans: See the topic dative covalent bond

Q.7 What is metallic bonds? Explain the metallic bonding with the help of a di

Ans: See the topic metallic bonding

Q.8 Define hydrogen bonding. Explain that how these forces affect the physical properties of compounds.

Ans: See the topic hydrogen bonding

Q.9 What are intermolecular forces? Compare these forces with chemical bond forces with reference to HCl molecule?

Ans: See the topic intermolecular forces

Q.10 What is a chemical bond and why do atoms form a chemical bond?

Ans: See the topic introduction of chemical bond

Q.11 What is octet rule? Why do atoms always struggle to attaint be nearest noble gas electronic configuration?

Ans: See the topic introduction of chemical bonding.

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